Multiple Determinants of Pleasantness in Olfactory Stimuli

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INTRODUCTION

Odors have diverse influences on behavior that may potentially be understood by examining the dimensionality of olfactory perceptual space.

Pleasantness has been found to be a primary dimension of odor space[1], with some arguing that it is the sole dimension[2]. Many effects of odors have been attributed to this property. However, pleasantness itself is complex - odors can be pleasant in many qualitatively different ways.

The aim of the current study is to determine the sub-components of odor pleasantness and the accompanying neural correlates, using covariance between pleasantness ratings and neural patterns of activity.

E.g. both roast turkey and lavender might smell "pleasant" – but not for the same reason.

METHODS

Ratings
Ratings were obtained for 47 odors from ≥25 participants each, along the following dimensions on a 9 point scale: Pleasantness and Intensity, Valence and Arousal, Dominance and Craving

To measure familiarity, participants were asked to guess the identity of the odor, then rate their confidence on a 9 point Likert scale.

fMRI
21 participants were exposed to 12 odors (a subset of odors used in Study 1). Each session was divided into 10 blocks, with each scent presented once per block in random order (Each odor was presented 10 times).

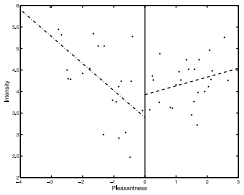
Analyses:
General Linear Model (GLM)
A GLM analysis was carried out to identify brain regions for which pleasantness and intensity ratings predicted parametric modulation of neural responses during aroma perception.

Partial Least Squares (PLS)
A PLS analysis was performed to identify latent variables in the covariance between behavioral reports of pleasantness and fMRI activity[3].

RESULTS

Pleasantness and intensity in olfactory perception

Figure 1. Pleasantness and intensity correlated negatively for unpleasant odors (r = -0.601, P = 0.00309), and positively for pleasant odors (r = 0.288, P = 0.163), similar to findings in other modalities (e.g. pictures and words).



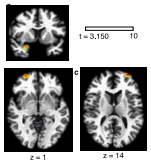


Figure 2. GLM results show that right amygdala correlates with intensity, while left mOFC and right MFG correlate with pleasantness ($p < 0.05$, corrected)

This result is similar to previous studies of odor pleasantness and intensity.

PLS Analysis

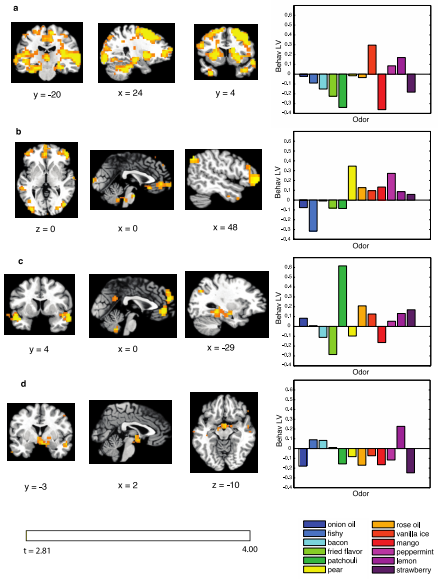


Figure 3. The PLS analysis yielded four significant latent variables (LVs).

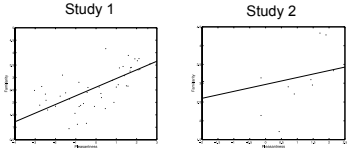
a) LV1 loadings correlated with familiarity ratings (r = -0.618, P = 0.0324) . Widespread regions contribute to the first LV, including the hippocampus, dorsal striatum, and regions throughout the middle frontal gyrus.

b) LV2 loadings correlated with pleasantness (r = 0.705, P = 0.0105) . Brain areas associated with this LV included medial and lateral OFC, similar to GLM results for pleasantness, and regions of the vmPFC.

c) Regions associated with LV3 included the hippocampus, superior temporal gyrus bordering the insula, and a region of the mPFC.

d) The mammillary bodies were found to contribute reliably to LV4. This structure has been identified as important in memory and emotion, and smell.

Familiarity and Pleasantness



(r = 0.668, P < 10^{-6}) (r = 0.347, P = 0.269)

Figure 4. Post hoc tests of the relationship between subjective familiarity and pleasantness.

CONCLUSIONS

Pleasantness has multiple determinants
- Four significant dimensions were found with behavioral PLS. Each of these was associated with unique patterns of neural activity.
- Familiarity was the primary driver of pleasantness in this dataset. This might be related to the mere exposure effect.
- The second LV was associated with the OFC and vmPFC, and correlated with subjective pleasantness. It is possible that these regions integrate diverse influences to produce an overall value signal.

Limitations and future directions
- Most of the odors used in this study were food-related. Future studies should examine a more diverse set of odors.
- There is reason to suspect that pleasant and unpleasant odors are qualitatively different. Future studies should examine these separately.
- These results can be used to inform studies aimed at determining mechanisms of olfactory influences on behavior. E.g. pleasant odors have been found to increase ratings of faces – is this due to increased feelings of familiarity? Are the same brain regions involved in these judgments?

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